OIL EXPLORATION AND DEVELOPMENT IN INDIA - 1974/75 TO 1986/87

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ABSTRACT

This paper discusses the exploration and development of oil and gas in India over the period 1974/75 - 1986/87. Section 1 is a review of the policy followed by the Indian government until 1973. It discusses the factors that have influenced the Government's decision to pursue a strategy of developing indigenous hydrocarbon resources through national efforts. Section 2 assesses the operations of Indian national oil companies in the production of crude oil and gas, in the saving of foreign exchange as a result of crude oil production, and the profits earned. The limited participation of foreign oil companies during this period is examined in Section 3, and Section 4 looks at future directions for the policy on exploration and development of hydrocarbons.

Key Words: Petroleum Deposits, oil-importing countries - India, Fossil Fuels, Energy Sources, Oil Wells, Exploration, Energy Expenses.

1

A REVIEW OF POLICY

The earlier Indian experience in developing its onshore oil resources and its experience with the multinational oil companies in the field of refining has been carefully and extensively recorded, and I shall not, therefore, discuss them in any detail here [1,2,3,4,5,6]. The most important lesson that emerged from that situation was the disadvantage that lack of information and indigenous expertise in the oil business, together with the urgent requirement to reduce the oil import bills imposed on India in its dealings with the companies operating in India, namely, Burmah-Shell, Caltex and Esso. To reduce the oil import burden, the Government with some difficulty, had the companies establish domestic refineries. Having secured that objective, it was important to have access to cheap crude supplies to feed the refineries. The refinery agreements of the 50s allowed the companies to import their own crude at international prices. It soon became obvious that the pricing policy followed by the foreign companies for crude oil was adding to the burden of oil import bills. Demands by importing-governments for lower prices were met by the oil companies with a counter request to governments to find cheaper sources of crude. This proved difficult when the companies themselves controlled most of the world oil supplies [7].

In the particular captive market situation India was, during the 50's and the early 60's, the only policy-response available to the Government was to seek to diversify its sources of crude. However, when the Government was able to find a bargain in the form of cheaper Soviet crude, it found itself unable to press the oil companies operating in India to use this crude in their refineries.[2] The Government at that time, had neither the ability to force the companies to use the cheaper crude nor the political will to nationalize them. Quite apart from the divisions within the Congress party on the issue, India's need for Western, and especially World Bank aid, clouded the issue. Instead, the Indian Government broke off the agreement to purchase crude from the Soviet Union [7]. But there was a fall-out from this episode, for after that incident the oil companies felt it necessary to give India some discounts in the face of Soviet competition.

From all accounts of exploration activity in onshore oil, it is evident that the search for oil was not undertaken very seriously before Independence [2,3.4,5]. The limited number of companies allowed access into India, more attractive investments elsewhere, and the international demand/supply situation of oil combined to result in little exploration activity in India. What little exploration did occur, was to meet the minimum contractual obligations, and to retain India as a captive market.

With Independence, the Industrial Policy Resolution of 1948, placed the petroleum sector under state control. Lack of financial resources, as also of operational capability, however, precluded the state sector from undertaking exploration on its own at the time. Hence the need to attract foreign companies. After Independence, two companies, Burmah Oil and the Assam Oil Company continued their operations and in 1949 they were joined by an US company, Standard Vacuum Oil Company [3,8]. In 1953, the Indian Government entered into a joint contract with Standard Vacuum, known as the Indo-Stanvac Project for oil exploration in West Bengal.

Between 1948-56, there were no other foreign companies involved in the search for oil in India. In 1955, a delegation went to the Soviet Union, Rumania, UK, the US and Latin America to study the oil industry in these countries, and to assess the external assistance it could gain for the country's oil ventures. This resulted in the strong involvement of the Soviet Union and Rumania in India's oil ventures, in the supply of exploration equipment and in the training of Indian nationals [8]. Soviet assistance led to the establishment of ONGC as an independent statutory commission in 1959, and later was instrumental in giving an impetus to the first offshore ventures. Thus, by the mid-sixties, with Soviet assistance, a national oil company with a fledgling capability and the perception that multinational oil companies were not interested in India, the Government took the decision to search for and develop indigenous oil.

The historical experience of the Indian Government in dealing with the multinational oil companies created a perception amongst decision-makers that indigenous expertise helps in a better bargain between the host-nation and the investing company, i.e., it improves the nation's capacity to influence directly and indirectly, the terms and conditions of a deal. A decrease in unequal bargains is believed possible only if the parties have the information to avoid being disadvantaged in such bargaining situations. The problem for

India was not just the fact of asymmetry in information, but also the high cost involved in achieving parity in information with the foreign investing entity. The situation in such a case could give rise to a 'moral hazard' condition where the entity with the greater knowledge and information uses it selectively in its transactions with the party who has the information disadvantage. One response to such a situation is to acquire capabilities. In India, the greater the number of instances that confirmed the suspicion that dependence on the foreign companies without domestic expertise led to foreign manipulation and consequent loss of national control over domestic activities, the greater was the movement toward acquisition of national capabilities [9].

It must be noted, however, that improvements in infrastructural and informational deficiencies are necessary but insufficient conditions for improvement in bargaining positions of less developed nations vis-a-vis foreign companies. The size of the country and its natural resource endowment, as well as the economic system it adopts, do represent constraints on improvements in the bargaining position [10]. That is, the larger its resources, the larger the size of its domestic market, the greater the governmental control over policy, the greater becomes the ability of the nation to handle asymmetric situations. While these parameters do introduce variations among nations in the strategies they adopt to improve their bargaining positions, the aspects of infrastructural and informational deficiencies remain very central to any such strategy, for the very reason that they are relatively easier to remedy.

In 1968, there were four options available to the Government for development of offshore oil: two would have involved collaboration, one was contractual, and the other an export-cum-technical collaboration arrangement [11]. The most attractive of the four was the offer of the Tenneco Oil Company. The company offered to bear the entire risk capital estimated at $12 million. On discovery of oil, Tenneco would enter into a joint venture arrangement with the Indian Government, with a 49% holding. The company would also help the Government obtain loans in the international market to meet its share of the development costs. The Government would have the first right of refusal in the company's 49% share in the crude, with a profit split of 78:22. Tenneco also agreed to a training programme for Indian engineers, as also the transfer of the management of the company to Indians after five years of production [5]. The package was attractive and yet it was not accepted by the Government. The main problem with the package was the need to share oil with Tenneco.

The other offers included one from the West German company, Bomin, to put up 75% of the risk capital and take 25% of the crude; the other was from Zapata (USA), which offered to bring in equipment, at a cost of $3.4 million for mobilization and $15,000 approximately as the daily operating charges. Zapata wanted 5% royalty on the oil produced, and was prepared to defer payments for 7 years [11]. The option actually favoured at the time was the fourth offer, from Mitsubishi of Japan, who offered to sell a jack-up unit to the Government for $14.65 million, in collaboration with the Offshore Company (USA), who would provide the drilling services on a daily fee basis of about $3400 [11]. The last offer was attractive because it enabled ONGC to be the operating company, with one jack-up unit, and with the drilling services provided by an international company.

By 1971, the Indian Government had decided to develop offshore oil through its operational arm, the ONGC. The work, however, did not commence until 1973-74, when offshore development was adopted as one of the responses to the oil crisis. While some attention was given to the development of offshore oil in the late sixties, the urgency of some action in that sector did not command significant political attention until 1970, when oil prices began to rise.

Offshore oil was first struck at Aliabet on the Indian West Coast, on March 19, 1971, a year after it had been spudded, and during a time when there was a major confrontation between the Government and the multinational oil companies, following the demands by the latter for increased prices for the imported crude. Following the Tehran Agreement of February 14, 1971, between the OPEC countries and the Western oil companies, new pressures had been generated within India for increases in the price of crude. The view of the Ministry at that time was that it might have to concede some increase in prices to the companies; it did however share the view of the OPEC governments that the oil companies should absorb the major part of the increase in taxation out of profits. The main lesson drawn from that situation was to look for alternative sources of crude, both domestically and abroad. Domestically, the policy response took the form of a five-year exploration programme to commence in 1973. The programme drawn up jointly with a team of Soviet experts, envisaged the drilling of 325 wells onshore and offshore, with a total drilling of 1,310,000 metres.

Thus in the early 1970s, the environment facing policy-makers in India was seen as one in which oil prices were high not because of any new demand or a physical scarcity of oil. The view of the policy-makers in India was that the prices were high because of the collusion between oil producing countries, and because it suited the international oil companies to have prices high. They had no incentive to pressure for reduced prices, as they did not bear the burden for the increased prices and it allowed them to invest in alternative energy sources. The critical variable in decision-making in India was, therefore, the price that India would have to pay for imported oil and the likelihood of that price remaining high for a long time. Not only were the prices seen to remain high, but the increased intensification of exploration effort by the oil-importing nations and the oil companies, were seen as having an escalating effect on the prices of equipment and services required for oil operations through sheer pressure on available supplies.

There is no doubt that the rising trend in prices caused enormous increases in the oil import bills. Unlike nations in the West, India could not respond to the higher prices by reducing consumption. In per capita terms its consumption and import volumes were marginal. Oil was crucial to the working of the economy, representing 25.9% of the total energy consumption in 1975-76, and 45.3% of the total commercial energy consumption [12]. In 1973-74, India depended on imported oil to meet 65.7% of its refinery throughput needs, (see Table 1). Thus, from a crude oil import bill of Rs.392 million in 1960-61, it rose to Rs.1067 million in 1970-71, to Rs.1464 million in 1972-73 and to Rs.4164 million in 1973-74. By 1980-81, however, the figure was much higher, at Rs.33,480 million, as Table 2 shows. The bill on oil imports increased from 7.84% of India's total imports in 1972-73, to 20.55% in 1974-75; by 1980-81 oil was representing 26.68% of total payments on imports. The implications of the increase in oil prices were much more serious if considered in terms of India's export earnings. In 1972-73, oil imports represented 7.43% of India's export earnings, the figure rose to 16.5% in 1973-74 and jumped to 27.55% in 1974-75. By 1980-81, 49.9% of export earnings were being tied up in oil payments as shown in Table 3. The burden of oil is seen in the fact that it came to represent over a quarter of India's total imports and half of its export earnings. Given the importance of oil to the economy and in the overall trade structure, rising oil prices tended to disrupt the economy via pressures on the balance of payments, terms of trade and income [13]. Thus, in 1972-73 the trade deficit was lower than it had been for some years. But subsequent to the rise in the prices of oil, and the steep rise in the cost of imports, not only of oil, but of oil-related products, the trade deficit increased from Rs. 2.5 billion in 1972/73 to Rs.9.8 billion in 1974-75. The sheer weight of this single commodity in the trade structure resulted in its being put at the top of the political agenda.

Table 1. Indigenous and Imported Oil in Domestic Consumption

Year	A Imports	B Indigenous Production	C Total Crude Throughput	A as % of C
	(figures in million tonnes)			%
1960/61	5.71	0.45	6.1	93.61
1970/71	11.68	6.82	18.4	63.48
1973/74	13.87	7.2	21.1	65.74
1975/76	13.62	8.45	22.3	61.08
1980/81	16.25	10.51	25.84	62.89
1981/82	15.29	16.20	30.15	50.71
1982/83	16.95	21.06	33.16	51.12
1983/84	15.97	26.02	35.3	45.24
1984/85P	13.64	28.99	35.6	38.32
1985/86	15.2	30.17	42.3	35.93
1986/87	15.5	30.5	45.7	33.92

Sources: Col. A & B: **Indian Petroleum & Petrochemical Statistics** 1984-85, 55; Col. C: **Economic Survey**, several issues.

Table 2. The Value of Oil Imports in India

Financial Year	Crude Imports A	A as % of C B	Total Imports C
	(Rs. Million)		(Rs. Million)
1960/61	392	3.48	11261
1965/66	396	2.81	14085
1970/71	1067	6.53	16340
1971/72	1470	8.06	18245
1972/73	1464	7.84	18674
1973/74	4164	14.09	29554
1974/75	9170	20.55	44614
1975/76	10518	19.98	52650
1976/77	11759	23.18	50740
1977/78	12462	20.68	60250
1978/79	12512	18.36	68140
1979/80	21875	23.93	91426
1980/81	33480	26.68	125492
1981/82	37360	27.33	136710
1982/83	40440	28.16	143600
1983/84	35410	22.46	157630
1984/85	34300	20.07	170921
1985/86	36870	18.76	196577
1986/87	21202	10.56	200835

Sources: Col.A: **Indian Petroleum & Petrochemical Statistics 1985-86**
Col.C: RBI, **Report on Currency and Finance**, several issues,
Economic Survey, several issues.

Table 3: Oil Import Bill as Percentage of Export Earnings

Year	Oil Imports A	Total Exports B	A as % of B
	(Rs. Million)		%
1970/71	1067	15350	6.95
1972/73	1464	16080	7.43
1973/74	4164	25230	16.50
1974/75	9170	33290	27.55
1976/77	11759	51420	22.87
1978/79	12512	57260	21.85
1979/80	21875	64180	34.08
1980/81	33489	67110	49.90
1981/82	37364	78060	47.87
1982/83	40440	89080	45.40
1983/84	35411	98720	35.87
1984/85	34300	115550	29.68
1985/86	36870	108946	33.84
1986/87	21202	125666	16.87

Sources: Col A: **Indian Petroleum and Petrochemical Statistics 1984-85,** p 11; Col B: *Ibid*, p 4. **Economic Survey 1987/88.**

2

AN ASSESSMENT OF THE OPERATIONS OF INDIAN NATIONAL OIL COMPANIES

The historical reasons discussed earlier have led to a strategy that has strongly favoured the almost exclusive involvement of the public sector in the search and development of oil in India. The two operational arms of the Ministry of Petroleum are the Oil and Natural gas Commission (ONGC) and Oil India Limited (OIL). the latter is far smaller than the former and has, so far, been of less significance, both in terms of capital, sales and areas of operation. To date most of the indigenous production has come from ONGC's operations on the West Coast, most notably, the Bombay High field.

ONGC is a corporate body set up by an Act of Parliament. OIL was initially a joint venture set up between the Indian Government and the Assam Oil Company in 1959, and taken over by the Indian Government in 1981. These companies have come to assume important positions in the public sector structure in India. The financial and the accounting systems of these companies while governed by government regulations, are similiar to those of other commercial oil companies. However, unlike the commercial oil companies, the national oil companies in India are subject to a number of governmental controls on their key financial parameters, that serve to bridge the "autonomy" of these companies. This occurs in a number of ways: (1) The investment programmes have to be approved by the Government, (2) oil prices are administered by the Government and

(3) external borrowing is allowed subject to the prior approval of the Government. Moreover, government controls over the oil companies occur at various levels of operations: exploration and production, pricing of crude, procurement decisions [9]. I shall not be discussing the nature of such controls in this study, but shall instead attempt to assess the performance of the NOCs, especially ONGC, in the search for and production of indigenous oil.

The Increase in Production

The public sector involvement in oil exploration and development activity increased the production of oil by as much as 26 times in two decades. In 1950, production of indigenous crude was no more than .26 million tonnes. By the end of 1969, as much as 35.78 million tonnes of crude had been produced in India. In 1972, the cumulative production of oil in India for the period 1889-1972 of onshore oil was 59 MMT, with no offshore production [14]. Table 4 shows the increase in oil production in the period since then. A continous increase is observed in the yearly production, with offshore oil coming to represent an increased proportion of the total indigenous oil. Almost all of the production from the offshore sector, comes from the Bombay High field, and all of it due to the operations of the ONGC. During the period 1976/77 - 1986/87, production of oil and oil equivalent gas from the onshore grew at an annual compound rate of 1.4% and from the offshore at a rate of 51.2%. Thus, the pace of production has been much higher from the offshore relative to that of the onshore

Table 4. Production of Crude Oil and Natural Gas in India

Financial Year	ONGC Offshore Oil (MMT)	ONGC Offshore Gas (MMM^3)	ONGC Onshore Oil (MMT)	ONGC Onshore Gas (MMM^3)	OIL Oil (MMT)	OIL Gas (MMM^3)	Offshore Oil as % of Total Oil Production
	A		B		C		
1975/76	nil	nil	5.24	638			-
1976/77	0.41	48	5.7	703			4.6%
1977/78	2.07	229	5.48	730	3.12	1431	19.2%
1978/79	3.31	386	5.62	731	2.70	1273	28.5%
1979/80	4.42	542	5.09	651	2.85	1345	37.6%
1980/81	5.0	673	4.28	680	0.80	525	47.6%
1981/82	7.98	1345	5.2	735	3.54	1656	49.3%
1982/83	12.88	2357	5.35	751	2.83	1466	61.0%
1983/84	17.4	3259	5.76	738	2.87	1598	65.9%
1984/85	20.14	4408	6.3	820	2.75	1641	68.9%
1985/86	20.82	5180	6.69	1401	2.63	1553	69.1%
1986/87	20.62	8150	7.24	1517	2.62	1631	67.7%

Sources: Cols.A & B: **Indian Petroleum & Petrochemical Statistics,** several years; Col. C: OIL **Annual Report 1986/87**

The Bombay High field is a giant field by world standards with potential oil in place reserves of over 6.6 billion barrels and recoverable reserves of over 1.3 billion barrels according to the 1979 CFP reserve estimates. The discovery of Bombay High enabled an accelerated rate of extraction of indigenous crude, which by the end of the 1970s was twice that in the beginning of the decade.

An Economic Evaluation of the Investment in Bombay High

Investment in Bombay High has been very rewarding, occurring, as it did, in a decade of high oil prices. To reflect this increase in international oil prices, the Government allowed the NOCs a higher base price per metric tonne, a matter I shall discuss a little later. Discounted cashflow rate of return taken at 1970/71 prices for the 10-year period 1976/77- 1985/86 was as high as 112%. In current prices this was about 130%. Net present value, assuming a discount rate of 12% is Rs.5518.78 million at 1970/71 prices, and Rs.17387.61 million at current prices. The data and the calculations are given in Table 5.

TABLE 5: Financial Returns from Exploitation of Bombay High Field

(figures in Rs Mn) (1970/71 Prices)

Year	Revenues Oil % Gas	Productio Costs	E % D Costs	Statutory Charges	Corporation Tax	After Tax Net Casflow	Discount Factor 12%	Discounted Cashflow
1976/77	90.00	0.00	250.74	27.80	0.00	-188.54	0.89	-168.37
1977/78	503.20	50.40	388.40	120.50	13.10	-69.20	0.80	-55.15
1978/79	897.80	80.00	224.30	176.40	22.30	394.80	0.71	281.10
1979/80	1065.90	81.90	258.10	197.20	131.40	397.30	0.64	252.68
1980/81	1071.50	150.20	348.50	189.10	0.00	383.70	0.57	217.56
1981/82	2886.20	231.70	589.30	618.60	428.30	1018.70	0.51	516.48
1982/83	5856.70	299.60	1192.70	1098.70	1222.00	2043.70	0.45	923.75
1983/84	8247.90	315.90	1156.30	2166.00	1928.90	2680.80	0.40	1083.04
1984/85	9077.60	398.70	1042.90	2362.00	1656.40	3578.00	0.36	1291.66
1985/86	9448.55	396.40	914.70	2346.80	1138.40	3652.25	0.32	1176.02

i= 12%
IRR= 112%
NPV = 5518.78

figures in Rs Mn) (Current Prices)

Year	Revenues Oil & Gas	Productio Costs	E & D Costs	Statutory Charges	Corporation Tax	After Tax Net Casflow	Discount Factor 12%	Discounted Cashflow
976/77	159.00	0.00	442.80	40.20	0.00	-324.00	0.89	-289.33
977/78	935.00	97.60	721.70	223.90	24.50	-128.70	0.80	-102.57
978/79	1668.20	148.70	416.80	327.80	41.40	733.50	0.71	522.25
979/80	2319.50	178.30	561.60	429.00	286.00	864.60	0.64	549.89
980/81	2757.00	402.00	876.60	486.40	0.00	992.00	0.57	562.46
981/82	8118.80	650.60	1657.60	1740.30	1204.75	2865.55	0.51	1452.83
982/83	16908.20	865.00	3444.30	3114.30	3528.00	5956.60	0.45	2692.38
983/84	26063.30	998.30	3654.00	6845.20	6095.20	8470.60	0.40	3422.12
984/85	30583.20	1348.00	3529.00	7993.00	5605.40	12107.80	0.36	4370.92
985/86	30212.00	1417.45	3270.80	8388.60	4071.00	13064.15	0.32	4206.66

i= 12%
IRR = 130%
NPV = 17387.61

urce: GOI, Ministry of Petroleum, Performance Budgets, Several
issues; ONGC Annual Report 1994/95

Gross Savings in Foreign Exchange

The increased production of indigenous crude has enabled considerable saving in foreign exchange. Table 6 indicates the gross foreign exchange saved per year as a result of indigenous production. Total foreign exchange saved during the period 1976/77-1985/86 is about $ 33528.7 million. The high international price of oil, therefore, justified the production of indigenous oil. The case for such production is further strengthened if account is taken of the premium attached to the foreign exchange saved.

Table 6. Gross Foreign Exchange Savings as a result of indigenous crude oil production during 1976/77 - 1985/86

Year	Production Total (MMT)	Price $/bbl	Price $/ton	Value of Indigenous Crud $ Million
	A	B	C	D
1976/77	8.9	11.66	85.4	760.06
1977/78	10.76	12.55	91.9	989.81
1978/79	11.63	13.01	95.4	1109.04
1979/80	11.77	20.43	149.8	1762.56
1980/81	10.51	30.17	221.2	2324.29
1981/82	16.20	33.00	241.9	3918.78
1982/83	21.07	33.25	243.7	5134.76
1983/84	25.78	29.00	212.6	5480.83
1984/85	29.19	28.33*	207.7	6062.76
1985/86	30.14	27.10*	198.6	5985.80
				33528.69

Sources: Col.A: **Indian Petroleum and Petro-Chemical Statistics, 1984-85,** p 22; Col.B: my calculations by taking prices for the last quarter of the year and the first quarter of the next year, and averaging. Source of the govt. selling prices Shell, published in Holmes and Cragg Financial Times Energy World, 1985, p 27; * **Petroleum Economist,** May 1987; Col.C: my calculations obtained by multiplying B by 7.33; Col.D: Col A valued at figures in Col C.

An Analysis of Pricing, Costs and Profits

Until 1975, indigenous crude was priced on the basis of the import-parity principle, but this was superseded by the recommendations of the Oil Price Committee set up in March 1974 to study the question of pricing of indigenous crude. In 1977, the Government fixed the base price of crude at Rs. 45/bbl, the figure being the recommendation of the Oil Price Committee after a calculation of the long run social marginal costs of exploration, development and production of a barrel of oil with a 30% rate of return to the national oil company. Over this base price, is the royalty and the cess. Total price, consisting of base price, cess and the royalty, thus amounted to Rs 58.8/bbl. Until July 1981, the price of offshore crude was greater than that of onshore crude. Thereafter, they were priced at the same level. Crude oil prices in India have always been lower than the imported price of oil (Figure 1). However, this fact does not affect the investment decisions of the NOCs, which are based not on the controlled prices but on the international prices.

The per barrel prices, costs and profits for the onshore and the offshore are shown in Table 7. Base prices were raised sharply from Rs.45/bbl to Rs.138.54/bbl in July 1981, representing an increase of 207%. This increase was allowed to reflect the trend in international prices and to allow an increased cash flow to the NOCs. Further increases in oil prices have been in the cess element which was raised from Rs.60/tonne in 1977 to Rs.100/tonne in 1981, a further Rs.200/tonne increase in 1983 and another Rs.300/tonne in 1987.

Production costs per barrel at 1970/71 prices have risen for both the onshore and the offshore. However, the offshore increase has been at a much slower rate of 4.1% relative to the 12.5% annual compound rate in the onshore over the period 1977/78-1986/86. Per barrel statutory charges like cess and roylaty have risen at an annual rate of 9.9% in the onshore and 9.75% in the offshore. Exploration and development expenditure at 1970/71 prices per barrel of onshore production has risen at a high 26.7% annual compound growth rate, while in the offshore, it has actually fallen by 12.3%. The behaviour of costs in the onshore and the offshore in current prices over the period 1978/79-1986/87 is shown in Figures II and III.

The fall in per barrel exploration and development expenditure witnessed in the offshore can be explained by the fact of increased production causing per barrel costs to fall. The sharp fall since 1985/86 is better explained with reference to the changes introduced in that year in the policy for the accounting of exploration and development expenditure [15]. These changes have had the effect of reducing the amount that is reported as an exploration and development expenditure, thereby maintaining the per barrel profit levels at the 1985/86 level, despite the sharp rise in per barrel production and statutory costs in 1986/87 and constant production levels.

The changes have been introduced at three levels:

(1) Instead of amortizing exploration drilling cost incurred in a year in equal installments over a period of 15 years, all such expenditure is now accumulated until the explored area is declared a

success or a failure. This has the effect of postponing the amount that is declared as an exploration expenditure for a particular year.

(2) Unlike the earlier practice of writing off development expenditure and unamortized exploration expenditure in 10 equal annual installments from the date of declaration of the area as a commercial producer irrespective of the levels of production, the new policy requires that the amount be written off in proportion to the ratio of produced output to the total recoverable reserves of a field.

(3) Similarly, this ratio is being used to determine the amount that is to be depreciated each year where earlier, plant, equipment and other capital costs were depreciated on the basis of the diminishing balance method at rates set out under the Income Tax rules.

Table 7 and 8 show the sharp increase in per barrel profits in the onshore and in the offshore in 1981/82 following the increase in base prices allowed to ONGC. The high per barrel profit continued in the offshore, but fell in the onshore. The close association in the movement of administered prices and the profit levels in the early eighties is shown in Figure IV.

Table 7: Per Barrel Price, Costs and Profits Onshore, 1978/79 - 1986/87

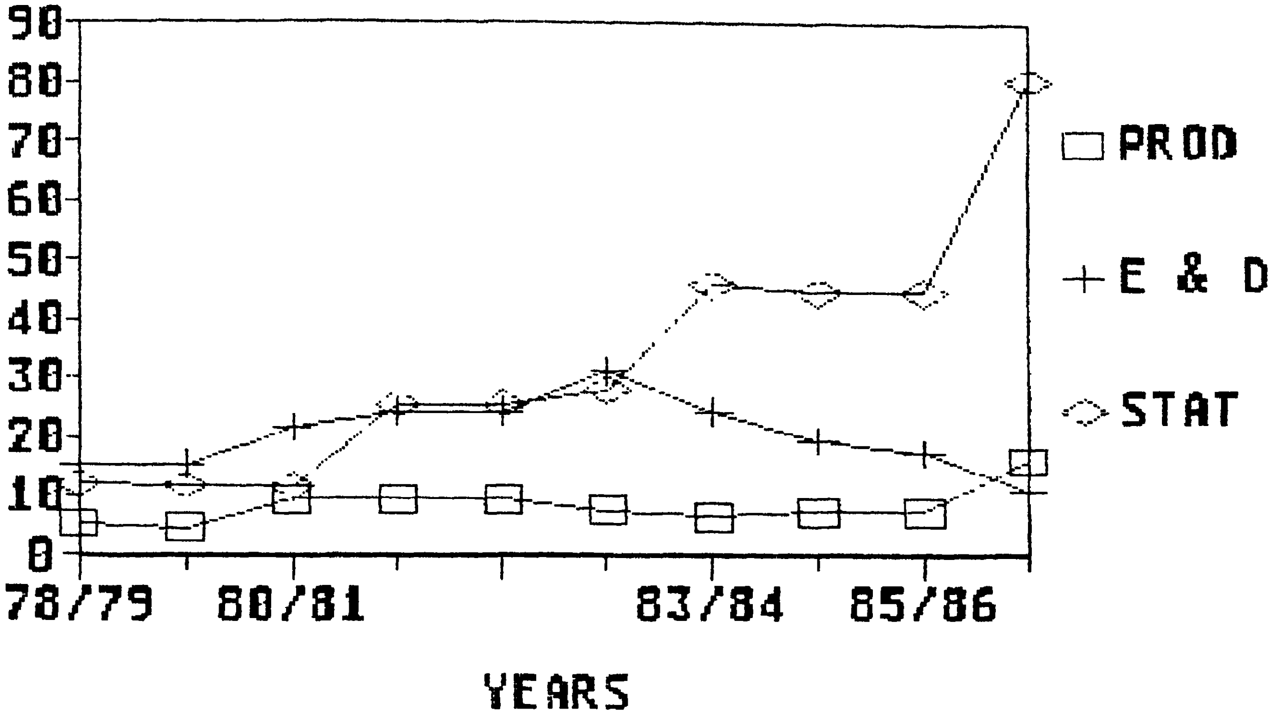
Years	Rs/bbl of Crude Oil		Costs/bbl			Gross
	Imported	Indigenous	Prod.	E & D	Stat.	Profits/bbl
1978/79	115.9	41.4	6.8	8.2	15.5	10.9
1979/80	184.1	41.4	8.9	10.8	27.4	-5.7
1980/81	279.7	43.9	9.1	17.5	23.8	-6.5
1981/82	331.3	43.9	19.0	16.6	23.0	-14.7
	331.3	160.4	19.0	16.6	23.0	101.8
1982/83	323.8	187.5	24.9	22.0	28.6	112.0
1983/84	300.9	187.5	33.9	39.5	46.6	67.5
1984/85	341.1	205.3	54.8	37.3	34.1	79.1
1985/86	330.4	205.3	30.4	56.0	33.4	85.5
1986/87	180.2	245.9	34.8	112.6	66.0	32.5

Table 8: Per Barrel Price, Costs and Profits - Offshore, 1978/79 - 1986/87

Years	Rs/bbl of Crude Oil		Costs/bbl			Gross
	Imported	Indigenous	Prod.	E & D	Stat.	Profits/bbl
1978/79	115.9	58.8	5.5	15.5	12.2	25.6
1979/80	184.1	58.8	4.9	15.5	11.9	26.5
1980/81	279.7	61.4	9.7	21.7	11.8	18.2
1981/82	331.3	61.4	9.6	24.5	25.7	1.6
	331.3	160.4	9.6	24.5	25.7	100.6
1982/83	323.8	187.5	7.8	31.3	28.2	120.2
1983/84	300.9	187.5	6.7	24.4	45.8	110.6
1984/85	341.1	205.3	7.5	19.7	44.6	133.5
1985/86	330.4	205.3	7.5	17.4	44.6	135.8
1986/87	180.2	245.9	16.2	15.7	80.4	133.6

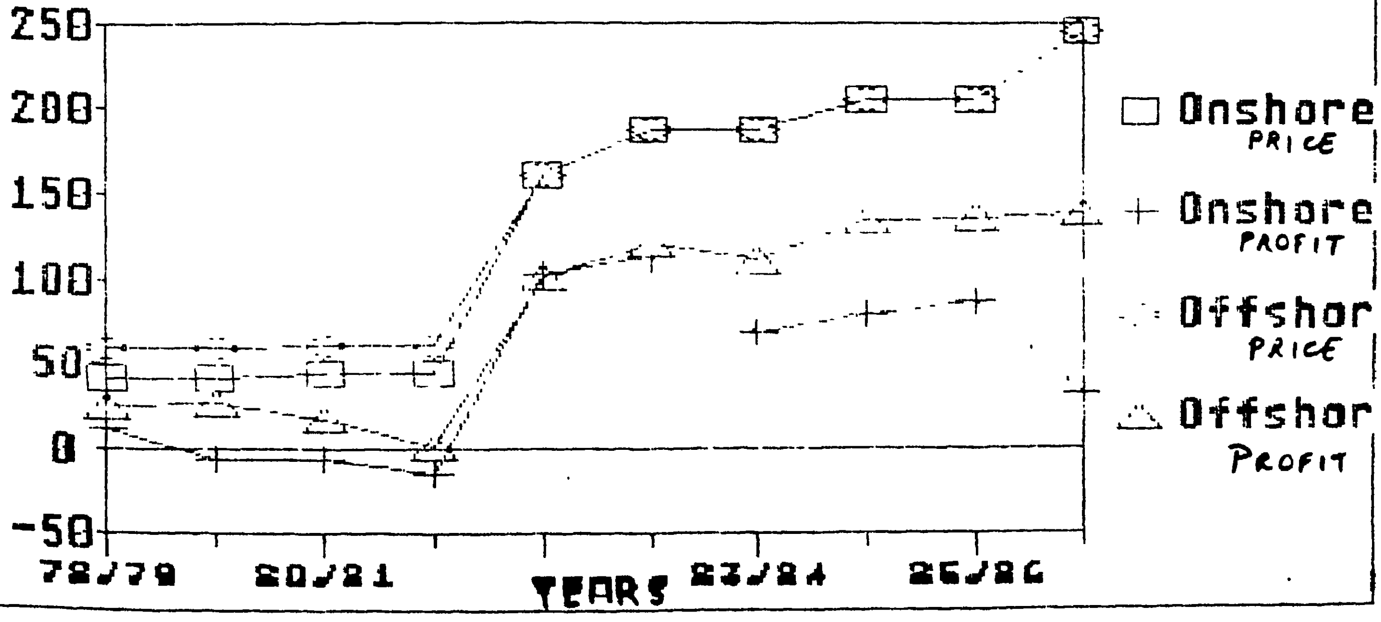
R BARREL OFFSHORE COSTS FIG III

PRODUCTION, E & D, STATUTORY



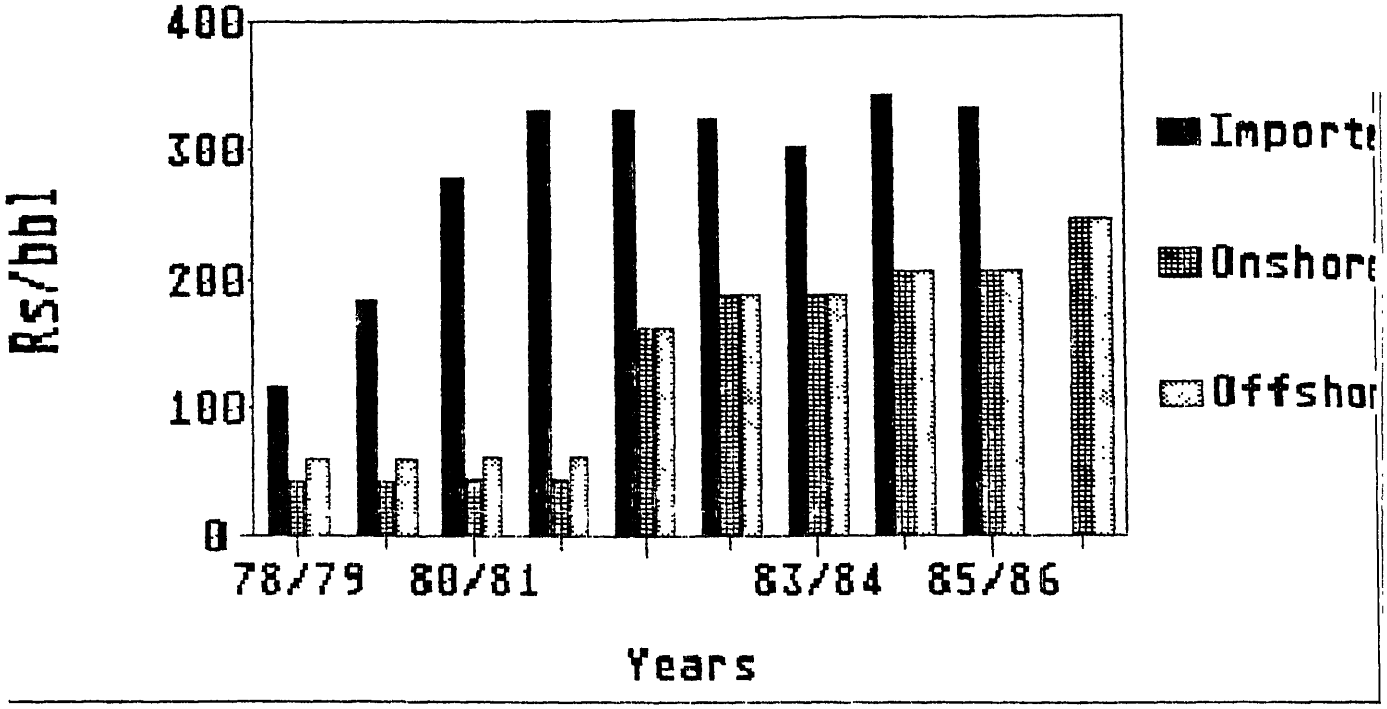
PRICE AND PROFIT PER BARREL FIG IV

ONSHORE & OFFSHORE



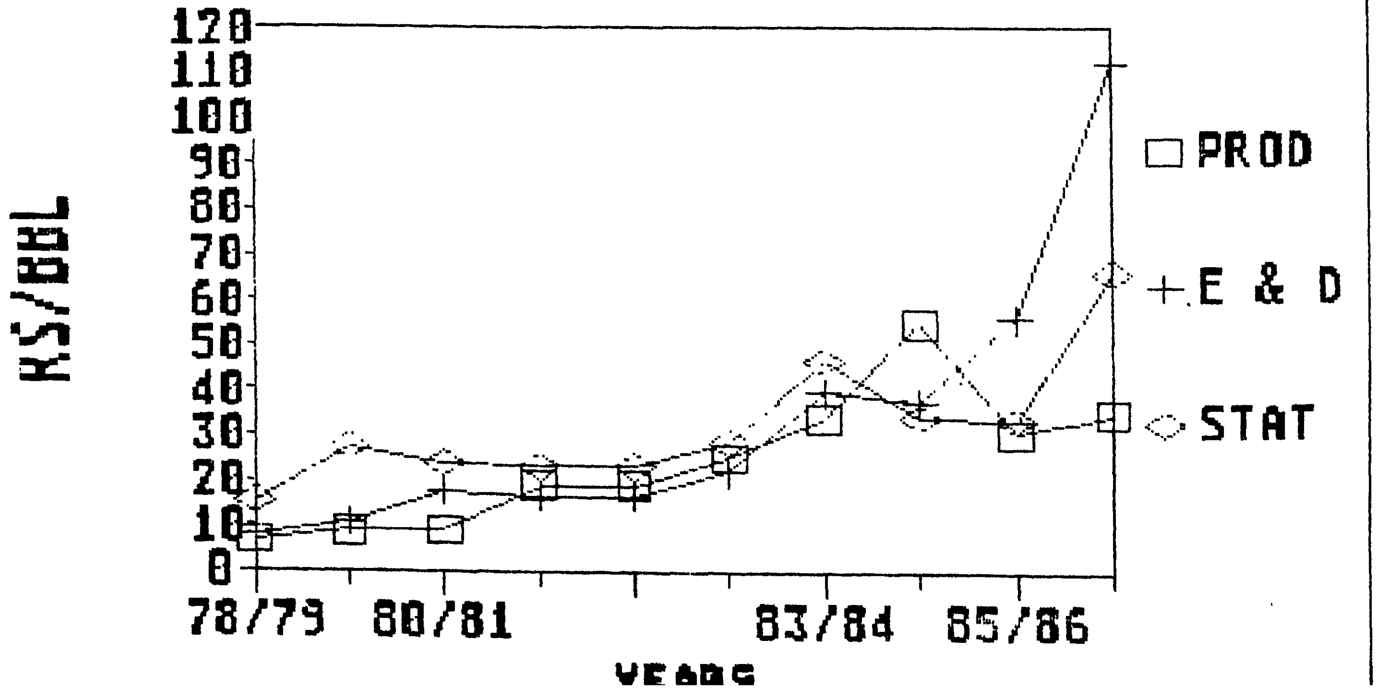
Per Barrel Price Fig I

Imported & Indigenous Crude



PER BARREL ONSHORE COSTS FIG II

PRODUCTION, E & D, STATUTORY



3

FOREIGN PARTICIPATION DURING THE PERIOD UNDER REVIEW

The anlaysis so far has concentrated on an assessment of the performance of the NOCs, especially ONGC. The Indian oil sector however, has, had limited foreign participation during this period which is the subject of the discussion in this section.

The rise in oil prices in 1973, presented the Government with two options: (1) to slow down its industrialization plans and, (2) to reduce the imports of crude by increasing indigenous production. The first option was rejected as it would reduce the growth within the economy and have longer term implications. The second option was both attractive and plausible. The 1973 crisis, and the indications that the upward swing in prices would continue, gave the production of indigenous offshore oil a commercial viability. The need to reduce the burden of oil imports provided the justification for involvement in offshore oil, and the rise in prices made such involvement economically possible.

In 1973, the Indian Government divided the offshore area into 10 blocks for exploration, of which 9 were offered to foreign contractors. The urgent necessity to limit the import of crude by finding more indigenous crude, called for an intensification of exploration efforts, and the country's financial and technical constraints created the need to involve foreign companies in the search for oil. However, the involvement was to be in selected areas, beyond the areas demarcated for indigenous effort, and where the technological capabilities required were beyond the existent domestic capability. While the acreage offered was to be on a selective basis, the choice of participants had to be on a global basis. The reasoning seems to have been that the established routes of foreign collaboration tended to operate too much under an imperfect market situation, where previous contracts or political/ economic relations gave these foreign agencies an unfair advantage over the host-country, in terms of the information the former had about the competence and bargaining position of the latter. In such a situation, it was felt that playing the market was a better strategy, as new entrants - independent oil companies and nationalized oil companies - would be willing to offer better terms in order to carve out a niche for themselves in a market that had been the preserve of the seven majors and their respective governments, that of the UK and the USA. In the opinion of the strategists, the choice of areas should be done in close consultation with the Indian agency actually operating in the offshore, and confined to those areas where the required technology was unavailable domestically, so that an award to the foreign agency would advance the domestic absorption of the new technology [11]. These areas excluded the priority areas reserved for the Indian oil company, where it had the expertise to operate.

The decision to invite foreign participation in 1973, thus represented a major shift in policy. But the shift seems to have been only in terms of the actors who would be involved in the offshore, for the terms that were to be offered to foreign companies were coloured and constrained by the above reasoning. Foreign companies were invited only because financial and technological constraints impeded the intensification of indigenous effort required in the search for oil domestically. But in doing so there seems to have been more emphasis on devising terms to safeguard the interests of the host-country rather than to attract foreign investment. The contractual terms of many oil-producing nation, developed and developing, have criticized for putting revenues before exploration. In the Indian case, the criticism seems to lie not so much on revenue considerations, as the very stringent conditions laid down to transfer technology to the Indian counterparts, the insistence of close association of ONGC in every phase of operation, the tough work and expenditure commitments, aspects of the Indian contracts which I shall discuss here.

Petroleum Agreements in the Offshore Sector

Offshore operations in India are governed by a single contract, and all such contracts are with the NOCs. The contractual form favoured for the participation of foreign oil companies was one that would retain the ownership of the oil discovered in the State so that the contractor acquires the title to its share of oil, only when the oil reaches the point of export. Such a contractual form is embodied in the production sharing contract (PSC)[16,17,18].

The Production-Sharing Contract

This form of contract, pioneered by Indonesia in 1966, was found suitable by the Government of India, and was adopted in the contracts drawn up with three independent foreign oil companies in

1974-75, and in the 1982 contract with Chevron. According to a former Petroleum Secretary, this form of contract was chosen at a time when there was a need for a state to have control over resources and its deposition; not enough expertise existed within the country to advise on the most appropriate petroleum arrangement nor was the political climate at the time conducive to any other form of contract, 'when there was far too much concern about oi company profits and being ripped off'. The main attractions of suc a contractual form for the Indian situation are that:

(1) the State does not have to contribute to the direct costs of exploration,
(2) the title to the oil discovered remains vested in the State,
(3) it allows the State to participate in the control of petroleum operations, through a management committee, although the forei contractor may still be the operator, and
(4) it generates an early cash flow for the State.
(5) it passes all of the geologic and most of the development risk to the contractor.

Under this type of contract, the production of oil is split int "profit oil" and "cost oil". And the profit oil is shared between th state company and the foreign oil company on some sliding scal formula. Thus the Government receives a revenue, from the beginning o production, through its share of revenue, for cost recovery is limited to a certain proportion of the total production. It is observed fro the enumeration of the attractions, that the salient fact of the PS is that it allows flexibility in the framing of terms, and a great involvement of the host-country, and less risk than the joint-ventur or the service contract.

The Groups involved in the offshore in 1974 were Independents, and included:

1. **the Natomas Group** (Natomas, Carlsberg, Crown Central Petroleum

and Lone Star Gas] who had a contract with ONGC for 24 years in the Bengal-Orissa basin. The Group drilled two dry holes on a 10,900 square mile tract. The tract was reduced to 1930 sq.miles by August 1976, and by May 1977, they began to lose interest in the venture.

2. **Reading & Bates Offshore Drilling Group** [Reading & Bates, Mapco, and Terra Resources], whose offshore well in the Gulf of Kutch was abandoned dry at 15,000 feet. Their original 10,930 sq.miles of exploration area too were reduced to 1930 sq.miles in two years. Both Groups terminated their contracts on August 1, 1977.

3. **The Canadian Asamera Group** [Asamera Oil, Canadian Superior Oil, and North Canadian Oil] who had a contract with ONGC for 24 years, from November 1, 1975, in the Gulf of Mannar. They too left after completing the minimum obligations.

The terms of the contract with Reading & Bates, which is indicative of the contracts concluded with the other two oil companies, are laid out in Chart I. The period 1977-80 saw no further foreign company involvement in exploration for oil in India.

After the 1979 rise in oil prices, decision-making for the oil sector was considerably pressed by the external environment. There were basically two options available to the Government:(1) either to increase production through ONGC, or (2) get foreign contractors to increase production. During this time, the burden of paying for oil imports and finding the foreign exchange to do so resulted in policy being pressured from two lobbies within India: the economic lobby, essentially the Ministry of Finance and the Planning commission, who pressured for self-sufficiency in indigenous oil given the paucity of foreign exchange to finance imports, and the nationalist lobby, who called for self-reliant responses to the crisis. It was decided then that the major input would come from ONGC, but because of the inadequacy of risk capital, foreign involvement in the oil search was also to be encouraged.

The First Round of Bidding- 1980

17 offshore and 15 onshore tracts were offered to companies in this round of bids. The 32 blocks were offered to 34 companies selected from an initial list of 67, that had responded to the Government's invitation. Of these 19 were from the United States, 3 from the UK, 2 each from France and Canada, and one each from Rumania, Brazil, Spain, West Germany, Singapore, and Italy [19].

None of the 34 oil companies, shortlisted and offered blocks, made any bids for onshore areas, and only 7 offshore blocks attracted bids from a dozen companies. In the final count, the number of bidders dropped to three - Chevron Overseas Petroleum Corporation of the United States, and two state companies; Pemex of Mexico and Deminex of West Germany. Two years after the initial decision, the Indian Government finally awarded an offshore block, called Saurashtra II, on India's west coast to Chevron. The terms of the contract are laid out in Chart I.

An analysis of the 1974 Indian contracts and the Chevron Contract of 1982, serves to indicate the approach of the Indian Government to foreign participation, and the purpose of such involvement in its overall strategy. The non-export clauses for example, are an important element of such contracts. According to these clauses the share of the contractor, both cost oil and profit oil, cannot be exported from India until India achieves self-sufficiency.

The non-export clauses are among the more unattractive clauses in the contractual terms offered by India, but the ones that are economically and politically unavoidable, given that India's oil requirements are such a drain on its foreign exchange. This is the basis for the non-export clauses in the Indian contracts, and yet, access to oil supplies is one of the main attractions for international oil companies, specially those that are integrated into refining and other downstream operations, for which they require access to secure supplies of crude or to those companies which carry 'briefs' to secure oil for their own home countries. The companies that may have no objection to the non-export clauses are:

(i) small oil companies who do not mind being paid in foreign exchange rather than crude,

(ii) those state oil companies who may enter into counter-trade arrangements.

The clauses would not have been as onerous if companies had refining interests in India, but after 1977, almost all of the refining capacity has been in the public sector. These clauses probably explain part of the reason why India's bid offers have attracted the non-major oil companies more than the majors. Contracts that do not allow the export of oil discovered, contain little incentive to search for oil, as this in no way increases the supply options of the oil company.

The production-sharing contracts of India, like those of Indonesia, include some elements of joint venture agreements. In the

Chevron contract, the Government of India had the option to purchase upto 50% of Chevron's working interest on commercial discovery of oil. On exercise of this option, the Government would have to pay the *pro rata* share of all costs in US dollars.

Indigenisation/Indianisation are important aspects of the contracts that were entered into in the mid-seventies as also in 1982. The right of the contractor to employ personnel in the operations is qualified by the requirement to keep the number of non-Indian personnel to the minimum, and to 'progressively replace these by Indian personnel'. The 1982 Contract requires that Chevron give preference to Indian sub-contractors in the provision of offshore equipment and supplies, or to such non-Indian sub-contractors who utilize Indian equipment, goods materials and supplies. Article VIII.10 of the Chevron contract requires that the contractor purchase goods, materials and supplies from Indian manufacturers to the possible extent of taking into consideration price, quality and delivery schedules. The Contractor is also required to 'prepare plans and programmes for industrial and technical training' of Indian personnel.

In the Indian contracts, government access to all the data and the relevant information related to the operation is very important. This requires that ONGC be associated with all operations and the interpretation of data. This requirement is inserted into the contracts not only to ensure control over the information gathered, but also to enable the ONGC to learn from the associaton. All Indian contracts include transfer of technology clauses. Transfer of technology and the rendering of technical assistance are however to be negotiated under separate royalty licenses or agreements.

From the discussion of the circumstances that led to the 1974 and to the 1981 invitation to foreign companies to search for oil in India, it can be said that the Indian government encouraged foreign participation when confronted with severe financial and technical constraints that impeded the national oil companies from meeting the oil requirements of the economy. The analysis of the provisions of the contracts indicate, however, that the Government, while driven to invite foreign companies by the constraints it faced, saw foreign participation as a means to increase national capability, in terms of information regarding national resources, and the learning process of its own nationals.

The Second Round of Exploration Bidding- 1983

The second round of bids were announced in November 1982. The Indian government invited 37 foreign oil companies to submit bids by 15 January of 1983, to explore for oil in 42 offshore and 8 onshore blocks. The companies included 22 from the USA and the state companies of seven nations [20]. In its invitation to the selected companies, the Government seemed ready to make concessions and to be willing to negotiate on the freedom of the oil companies to export the profit component of oil. The income tax payable by the companies was reduced to 56.375% from 73.05%. The second round of bids met with extremely poor response from the oil industry. Unlike the first round of bids, in which there were 67 pre-qualifying bids, this time there were just 4 or 5 companies that replied to the Government's invitation. By June of 1983, the Government decided to abandon the

The Indian government has had relatively little success in attracting foreign participation in all three earlier rounds. The 1974 round resulted in the signing of three contracts, the 1981 round resulted in the one contract with Chevron, and the 1982/83 round had no takers at all. A combination of factors serve to explain this reluctance by foreign oil companies to participate in Indian oil ventures: the belief by some oil companies that India does not have good geologic prospects, the belief of others that there is within India too much opposition to foreign participation, and the fear of yet other oil companies of arbitrary changes in Government policy [9]. Relative to the responses to the earlier rounds, the response to the 1986 round has been a success, given the signing of nine contracts with 1OCs. It becomes important to examine the differences between the 1986 situation and the earlier offers to understand the reason for this relative success.

The Third Round of Bids-1986

The unsatisfactory response to the two previous round of bids, led the Government to undertake a study of the models of incentives offered by countries like China and Indonesia to foreign companies for offshore exploration. The British Company, Guiness Peat was asked to do a study of nine nations including, Britain, Norway, Egypt and Spain for a comparative study of model contracts [20]. The Indian Government invited the foreign companies to bid for acreage both on the East and the West Coast of India. In a major effort to attract foreign involvement in an environment seen as hostile to new investment in exploration by oil companies, the Government put up 27 blocks ranging in sizes from 1500 sq.kms to 30,000 sq.kms. These blocks include 1 in the Saurashtra Basin, 8 in the Konkan-Kerala Basin, 5 in the Cauvery Basin, 2 in the Palar Basin, 7 in the Krishna-Godavari Basin,and 4 in the Mahanadi Basin. The scenario envisaged by the officials of the Government of India, is of an upward movement in oil prices by the early 1990s, and therefore the current period is seen as the best time to invest in exploration, because the low equipment and service charges and India's cheap manpower, make it worthwhile to invest. When the oil is ready to come on stream the price of oil is seen as being high enough to make it commercially attractive to develop this oil.

In an effort to combat the low oil prices, and to beat the international competition for scarce investment funds, the Government put together a package of terms and conditions which differ significantly from the earlier rounds. The main changes in this offer as compared to the earlier offers are [22]:

(1) the "seismic option" i.e., an operator can pull out of a licensing arrangement, if the seismic data fails to give any encouragement to drill

(2) no signature or production bonus is specified

(3) no minimun expenditure obligations in drilling only physical commitments

(4) profit oil share based either on post tax rates of return or multiples of investment recovered

(5) no ring fencing of blocks for corporate tax purposes

(6) suitable provision for production and the pricing of gas

(7) corporate income tax at 50%.

The "softening" in terms in this round are mostly at the bottom end of the scale, which is wise, since the decision to invest depends very much on the risk/reward structure at the commencement of operations. The PSC in the third round has elements of a risk-sharing contract, since it places no fixed limit on cost recovery to the company. The offer also provides a choice of options in which to define the profit share. Thus the company can either base it on the cumulative net cash inflow as a multiple of exploration costs and development costs, or base it on post tax rates of return. Thus the company can protect-itself by choosing the option that reflects its risk/reward profile. Chart II at the end of this section gives th main elements of the 1986 model contract.

It can be argued that the relatively better response to this round compared to that of the earlier rounds is mainly on account of three reasons:

(1) In a climate of oil gluts, non-exportation clauses in the Indian contracts become less unattractive, as the oil company finds a sure market for its output. The problem for , the large international oil company in a situation of oversupply in the international market, is one of ensuring the sale of the additional barrel of oil.

(2) The contractual terms offered have taken into account the more uncertain international environment facing the IOCs and have provided a more attractive risk/reward structure, through an avoidance of bonus payments, a greater flexibility in the

percentage of production allowed under cost recovery and in the determination of production shares.

(3) the provision of pre-exploration data by the national oil companies to the interested parties has enabled them to reassess their perception of the geologic potential of the Indian sedimentary basins.

Another important change perceived by the IOCs is the greater degree of liberalization towards foreign investment and goods since 1984. This has served to mitigate their perception of Indian opposition to foreign investment. As their perceptions change in response to the events in India so does their policy towards investing in India.

Chart I: Production-sharing Contracts - India

Comparison of the Reading & Bates/ONGC , Chevron/ONGC, Contracts

COMPONENT	READING & BATES/ONGC (1974)	CHEVRON/ONGC (1982)
Area	Gulf of Kutch	Saurashtra II
Effective Date	August 1, 1974	March 26, 1982
Duration	24-27 years Exploration, 3+2+2	22 years Exploration 3+2
Relinquishment		
After Phase I	Left with: 5000 Km^{2}	Left with: 9250 Km^{2}
After Phase II	Left with: 2500 Km^{2}	
After Phase III	Left with: Producing areas.	Producing areas
Signature Bonus	US $1 million	US $1 mn.
Discovery Bonus	US $1 million	US $1.292 mn.
Production Bonus	US $3 mn.at 40,000b/d & US $3 mn.at each multiple over the initial 40,000 b/d	No bonus is specified
Exp.& Drilling Obligations (minimum)	Phase I: 1 well & $2.8 million Phase II: 2 wells and $4 million Phase III: 3 more wells and $4 million	Phase I: 3 wells and $29 mn Phase II: 2 wells and $18 mn.
Cost Recovery	40%	Over 5 years.
Production Share Co/Govt	35/65 < 75000 b/d, 30/70 < 100,000 b/d 27 /72 < 150,000 b/d, 25/75 < 250,000 b/d and 20/80 over 250,000 b/d	On a sliding-scale formula - multiples of investment recovered
Taxation	No tax on profit oil, Royalty paid by ONGC;	No import duties 56% income tax
Management	Joint 3:3	Joint 4:4

Source: The chart is based on: 'The Offshore Exploration/Exploitati Contract dated 24 May 1974 between Reading & Bates/Terra Resources/MAPCO and Govt/ONGC' published in Basic Oil Laws and Concession Contracts: Asia and Australasia. [Supplement No. 53 1977]The Barrows Co., New York. 'Contract dated 26th March 1982 between Chevron, ONGC and President of India' (Barrows, Supplement No. 86, 1985)

Chart II: 1986 Model Contract - India

COMPONENT	MODEL CONTRACT (1986)
Area	
Effective Date	
Duration	Exploration 8 years
Relinquishment	
Phase I	Left with 75%
Phase II	Left with 50%
Phase III	Left with producing areas
Signature Bonus	No Bonus specified
Discovery Bonus	
Production Bonus	
Exp.& Drilling Obligations	Physical commitments, not financial
Output Share	Multiples of investment recovered or on post tax rates of return
Taxation	No royalties or import duties; 50% income tax
Management	Joint 5:5

Source: Government of India, Ministry of Petroleum

4

FUTURE DIRECTIONS

One of the crucial factors influencing decision-making for the oil sector tends to be the price of oil. In the seventies and the early eighties, rising oil prices in the future were the preferred scenarios of most policy-makers and oilmen. It still continues to be so with some, but there are others who believe that the price of oil will not rise to the levels witnessed in the last 1970s and early 1980s.

Conventional wisdom has it that the low prices since 1983/84 will have the effect of increasing consumption of oil, of reducing exploration and development effort in non-OPEC countries and investment in alternative energy sources [23,24]. The impact of this has been an increased demand for oil and reduced non-OPEC ability to meet this demand. The net result would be a renewed dependence on OPEC sources and the consequent ability of OPEC to control oil prices again. The projection, therefore, is that oil prices will be high again by the mid 1990s.

The challenge to this view is that oil prices will not be able to rise to the level of the late seventies and the early eighties, because market forces (i.e., the interaction of demand and supply of oil) are continously eroding the power of those who seek to control prices through edict [25,26,27]. The wide divergence between the price of oil and and its cost of production, the existing excess production capacity, the increased efficiency of energy appliances still waiting to enter the market, the possibilities of new discoveries from the unexplored and underexplored areas of the world, all point to a downward pressure on prices. The opinion of economists subscribing to this view is that oil prices will tend to fluctuate between a competitive floor of $8/bbl in the short run, in 1985 dollars, below which there will be cutbacks in US production, and $5/bbl in the long run, which is the amount necessary to maintain a flow of investment into new reserves and capacity in non-OPEC countries and a ceiling of $20/bbl envisaged by OPEC [25]. More generally, it has been argued that a range between $14 - $18/bbl in real terms is a necessary condition for an expanding oil industry [27].

The point of this discussion is that it is impossible to forecast the price of oil in the next decade. In the face of such uncertainty, what are the likely directions that the Indian government should take in the exploration and development of hydrocarbons? To discuss this, it is necessay to examine the functions the two activities perform and how they are perceived from a national interest point of view.

Exploration activity provides information which serves two functions: (1) to expand the supply capacity and (2) to produce information about the resource stock [28]. While the first function is obvious, it is the second that is of importance to my analysis. Information that exploration activity provides relates to the size, location and the characteristics of deposits [28]. However, the information that is provided is very limited at the exploration stage, and the process of appraisal and the development of wells is required for any meaningful appreciation (or depreciation) of reserves. The exploration phase is but the first phase in a long process of acquiring knowledge about the size of the recoverable reserves. Along with the appraisal of a field, it does, however, firm up the oil-in-place figures. The continued development of the field is required to have a better estimate of the size of the recoverable reserves. As development activity continues, the reserve figures tend to appreciate, except in cases where the initial expectations about the reserve potential tend to be incorrect [29].

'Prognosticated resources' are thus in no way indicative of the potential for self-sufficiency in hydrocarbons; only of the potential exploration activity that needs to be undertaken. Geological in-place reserves are better indicators of the hydrocarbon potential of the particular basin. Under existing economic and technical conditions, the recoverable part of the oil-in-place represent proven reserves. This figure is only a small protion of the in-place reserves and is a dynamic one, changing as the economic and the technical conditions change.

Given that exploration is only a first phase in a complex process of information-gathering about the country's resources, it becomes essential that it should take place irrespective of the price situation. This is reinforced when account is taken of the time-lag (ONGC estimates it to be 15 years in India) involved between the establishing of reserves and their production.

The decision to develop and produce oil tends to be more price responsive. Thus, the decision to stop development investment may have to be taken if the price per barrel falls below the average development and operating costs per barrel. If the price of oil falls below the production cost/bbl then production of indigenous oil may need to be shut down and the country would be better off importing oil.

In what follows, I carry the study a little into the future and attempt to do a simplified, aggregated analysis of future oil supplies from the offshore. As on 1.1.85, of 15.39 billion tonnes of prognosticated hydrocarbon resources, 3.651 billion tonnes have been converted after exploratory drilling into in-place geological reserves of hydrocarbons. Of this 2.591 billion tonnes are those of the Bombay Offshore, that is 71% of the established reserves for the whole of India have been in this one basin. The 3 basins - Bombay Offshore, Cambay and Upper Assam - have 60% of the prognosticated resources and it is in these 3 basins that 97% of the reserves have been established.

The proven reserve figures as on 1.1.86 were 212.47 MMT in the onshore, and 345.54 MMT in the offshore. The reserves to production ratio (R/P) has fallen quite steeply since 1980, from 39 to 16.5 in 1985. Appreciation of reserves in 1986 has led to an increase of R/P ratio to 18.5. The R/P ratio is an important tool in planning. It can be used to calculate the required addition to reserves when production is growing at the defined rate or to calculate the level of production, if the addition to reserves required to maintain growth cannot be sustained [29].

At this point, I shall attempt a forecast of reserve additions in the Bombay Offshore field until the year 2010, following the work of Adelman and Jacoby [30]. The model uses the concept of proven reserves as its basis. The forecast is along deterministic rather than probabilistic lines, although the latter is a more appropriate method for the forecasting of oil supplies. In the approach followed here gross additions to proved reserves in any year are forecast using development rig years as a proxy for the investment which results in appreciation of these reserves. Before this is done, however, it is necessary to calculate the addition to reserves that will be required in 2010. I do this through the use of the R/P ratio when production is assumed to be growing at a given rate.

A simple way of expressing the proven reserves required in 2010 is through the use of the following expression:

$$\text{RESERVES}_{2009/10} = \text{RESERVES}_{85/86} - \Sigma\text{PRODUCTION}_{85/86-2009/10} + \Delta\text{RESERVES}_{85/86-2009/10} \qquad (1)$$

That is, the reserves required in 2009/10 are the reserves in 1985/86 plus the gross additions to reserves during the period 1985/86-2009/10 minus the the quantity produced during this period. Proven reserves of crude oil in 1985/86 were 558 MMT, of which offshore reserves were 345.54 MMT. The 7th Plan Subgroup on Exploration, Development and Production of oil and gas (1985/86 to 1989/90) projected production to be 160.88 MMT over the VII Plan period. The Subgroup's projections assume a 4% average annual growth rate over this period. Assuming this as an average growth rate in production until the year 2000, and a 5% growth rate until the year 2010, total production during the whole period 1985-2010 is as follows:

VII Plan - 160.8 MMT
VIII Plan - 195.7 MMT
IX Plan - 238.1 MMT
X Plan - 303.9 MMT
XI Plan - 387.8 MMT

1286.3 MMT

Annual average production over the XI Plan is 77.56 MMT. If the R/P ratio of 18.5 is assumed as the norm for 2010, then a production of 77.56 MMT of crude requires reserves of 1435.6 MMT in 2010. Given that about two-thirds of reserves are in the offshore, chances are that about 947.5 MMT will be established in the offshore and 488.1 MMT in the onshore. Production of offshore crude is also assumed to be two-thirds of total production, i.e., 824.10 MMT, as has been the case in recent years.

I am limiting my forecasting exercise to the offshore and, more specifically, to the Bombay Offshore field. Therefore, to have proven reserves in the offshore in 2010 of about 947.5 MMT, the additions to proven reserves during the period 1985/86 to 2009/2010 will be given by:

$$\Delta RESERVES_{85/86\ -\ 2009/10} = RESERVES_{2009/10} - RESERVES_{85/86} + \sum PRODUCTION_{85/86\ -\ 2009/10}$$

$$= 947.5 - 345.54 + 824.10$$

$$= 1426.1$$

That is, with an assumed R/P ratio of 18.5 for the onshore and the offshore taken together and production assumed to be growing at an an average rate of 4% till 2000, and 5% till 2010, additions to the proven reserves in the offshore will have to be about 1426.1 MMT.

Data and Equations used in the model

OIIP in the Bombay Offshore = 2590 MMT

Proven reserves in 1985/86 = 345.54 MMT

The data for reserves, output, rig years till 1985/86 are actuals. Rig years from 1985-1990 are from the 7th Plan Subgroup. Assumptions with regard to rig-years made for the other Plan periods are as follows:

VIII Plan: 12 rig years
IX Plan: 12 rig years
X Plan: 15 rig years
XI Plan: 20 rig years

Forecasts are made with the base year 1985/86. The average reserves added per rig year (RA/RY) taken over the period 1976/77-1985/86 were 8.68 MMT. This figure multiplied by a decline coefficient, b_1, that is calculated annually, and the rig years give the additions to reserves in any year (dR). The results can be seen in Appendix 1. The proven reserves figure calculated as in eq. (1) gives reserves in 2010 to be 946.82 MMT, total reserve additions over 1985/86-2010 to be 1425.38 MMT, allowing a production of 824.10 MMT. To achieve this, the development rigs (or the investment) will have to be doubled by 2010.

This exercise is only a preliminary attempt at forecasting future oil supplies. It has been conditioned by the limited extent of data availability. If more disaggregated data is available, an attempt could be made at a probabilistic forecast of oil supplies. Thus, to meet the demand for crude in the year 2009/10, there is need to firm up reserves of oil. For this, the pace of development tivity will also have to be stepped up, which will require more nancial investment and much larger level of managerial input. is brings me to the question of the agencies that should be volved in the search for and the development of indigenous drocarbon resources. There are three distinct areas that are in ed of research in this context:

.) an examination of the costs and benefits associated with the development of indigenous resources by NOCs alone and by a mix of NOCs and FOCs;

2) the possible restructuring of the NOCs either in functional or geographical terms or both;

3) the design of optimal contracts for foreign oil company involvement in different environments.

APPENDIX I

FORECAST OF RESERVE ADDITIONS UPTO 2010 FOR THE BOMBAY OFFSHORE FIELD

	year	R(t) Pr. Res. MMT	Q Output MMT	RY Dvl. Rigs Rig Yrs.	RA, RY MMT	b1 Dec. Cff. –	dR Rs. Add MMT
	1976/77	175.28	0.41	0.10	1736.90	1.0	0.10
	1977/78	221.04	2.07	0.10	241.20	0.91	22.04
	1978/79	226.29	3.31	0.10	189.33	0.91	17.24
	1979/80	230.95	4.42	1.10	47.06	0.91	46.94
	1980/81	328.29	4.99	1.30	45.46	0.87	40.70
	1981/82	325.18	7.98	2.90	26.22	0.87	65.82
	1982/83	338.70	12.38	4.60	17.81	0.86	70.07
	1983/84	323.81	17.39	7.00	11.10	0.85	66.37
	1984/85	311.10	20.14	6.60	8.44	0.85	47.45
VII Plan	1985/86	345.54	20.82	5.70	8.68	0.83	41.06
	1986/87	365.78	20.62	8.20	8.68	0.81	57.96
	1987/88	403.12	19.92	12.20	8.68	0.79	83.90
	1988/89	467.10	21.92	10.40	8.68	0.76	68.52
	1989/90	513.70	24.32	10.40	8.68	0.73	66.05
VIII Plan	1990/91	555.44	25.29	12.00	8.68	0.71	73.52
	1991/92	603.66	26.30	12.00	8.68	0.68	70.52
	1992/93	647.88	27.36	12.00	8.68	0.65	67.64
	1993/94	688.16	28.45	12.00	8.68	0.62	64.88
	1994/95	724.59	29.59	12.00	8.68	0.60	62.22
IX Plan	1995/96	757.23	30.77	12.00	8.68	0.57	59.67
	1996/97	786.13	32.00	12.00	8.68	0.55	57.22
	1997/98	811.35	33.28	12.00	8.68	0.53	54.87
	1998/99	832.94	34.61	12.00	8.68	0.51	52.61
	1999/2000	850.93	36.00	12.00	8.68	0.48	50.44
X Plan	2000/01	865.37	37.44	15.00	8.68	0.46	60.44
	2001/02	888.37	39.31	15.00	8.68	0.44	57.31
	2002/03	906.37	41.28	15.00	8.68	0.42	54.33
	2003/04	919.42	43.34	15.00	8.68	0.40	51.41
	2004/05	927.58	45.51	15.00	8.68	0.37	48.90
XI Plan	2005/06	930.87	47.78	20.00	8.68	0.36	61.64
	2006/07	944.72	50.17	20.00	8.68	0.33	57.35
	2007/08	951.90	52.68	20.00	8.68	0.31	53.34
	2008/09	952.55	55.32	20.00	8.68	0.29	49.58
	2009/10	946.82	58.08	20.00	8.68	0.27	46.08
		1425.38	824.10				1425.38

Forecasts with base year 1985/86; Symbols used:

R(t)=R(t-1)+dR(t-1)+Q(t-1)

Q: Actuals until 1987/88; 7th plan Subgroup till 1989/90; @4% average compound growth rate till 2000;and @5% until 2010.

RY: Actuals until 1984/85; 7th plan Subgroup until 1989/90;assumed until 2010.

RA(t)=[R(t)-R(t-1)+E(Q)]/E(RY)

b(t)=1-{E(Q)+R(t)/2590}

dR=RY.RA.b(t)

Total Reserve Additions from 1985/86to 2009/2010 = 1425.38
i.e. R(2010)-R(1985/86)+E(Q) = 1425.38

Total Production over the period 1985/86-2008/2009 = 824.10

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